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Lifetime Performance of Nili-ravi Buffaloes in Pakistan

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ABSTRACT : Data on 1,037 Nili-Ravi buffaloes from four institutional herds were used to study lifetime milk yield, herd life, productive life and breeding efficiency. A general linear model was used to study the environmental effects while an animal model having herd, year of birth and age at first calving (as covariate) along with random animal effect was used to estimate breeding values. The lifetime milk yield, herd life, productive life and breeding efficiency averaged 7,723±164 kg, 3,990±41 days, 1,061±19 days and 64 percent, respectively. All the traits were significantly ($p<0.01$) affected by the year of birth and herd of calving, while the herd life was also affected ($p<0.01$) by the age at first calving. The heritabilities for lifetime milk yield, herd life, productive life and breeding efficiency were 0.093±0.056, 0.001±0.055, 0.144±0.079 and 0.001, respectively. The definition for productive life, where each lactation gets credit upto 10 months had slightly better heritability and may be preferred over the definition where no limit is placed on lactation length. The genetic correlation between productive life and lifetime milk yield was low but high between productive life and herd life. The selection for productive life will increase herd life while lifetime milk yield will also improve. The overall phenotypic trend during the period under the study was negative for lifetime milk yield (-280 kg/year), herd life (-93 days), productive life (-42 days/year) and breeding efficiency (-0.36 percent/year), whereas the genetic trend was positive for lifetime milk yield (+15 kg/year) and productive life (+4 days/year). (**Key Words :** Lifetime Traits, Heritability, Estimated Breeding Value, Nili-ravi, Pakistan)

INTRODUCTION

Economic return from dairy animals depends on lifetime performance. The prediction of expected correlated response to selection based on early performance and development of selection schemes for genetic improvement in lifetime traits are likely to be more beneficial. Buffaloes are generally culled for reproductive failures, low yield, mastitis and other health problems (Cady et al., 1983; Ahmad et al., 1992). Lifetime milk yield is thus a commonly studied trait to document lifetime performance. Most of the worker estimated the lifetime milk yield based on the all lactations (Ali 1989; Juma et al., 1991; Dutt and Taneja, 1994; Madhv, 1994). Some have restricted to 3-5 lactations to estimate the lifetime milk yied (Sharma et al., 1996; Patel and Tripathi, 1998; Raheja, 1998). Lifetime milk yield thus varies among studies. Lifetime milk yield for different breeds of buffaloes ranged from 3676 to 9,993±338 kg (Biradar et al., 1991; Dutt and Taneja, 1994) in Murrah and Surti buffaloes. In Pakistani buffaloes lifetime milk yield ranged from 7,834±6 to 8,012±236 kg in a Nili-Ravi herd as reported by Ali (1989) and Ahmad (2004).

Herd life is another important determinant of lifetime performance. There are two different definitions of herd life; duration (in days) between the birth and disposal (Smith and Quaas, 1984) and length of time between first calving and censoring (Dutt et al., 1996; Rao and Rao, 1996; Raheja, 1998; Ali, 1999). For buffaloes it has been reported to range between 2,015 to 4,490 days (Cady et al., 1983; Ali, 1989) when lactations were not truncated for any length.

Productive life (or longevity) is also used to describe lifetime performance. There are different ways to define it. VanRaden and Klaaskate (1993) defined it as productive age upto 84 months of age giving credit up to 10 months per lactation and accumulated over all lactations until the cow was culled or reached 84 months of age. The limit of 84 months made distribution somewhat more normal. Alternative limits for maximum months were also tested but were discarded because of slightly lower heritability. The heritability increased gradually from 0.03 at 36 month to

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0.8 at 84 month. Genetic correlations of early with completed longevity ranged from 0.92 to 1.00. The suggested definition has been used in later studies as well (VanRaden and Wiggans, 1995, Weigel et al., 1998; Abdullah et al., 2002) and is being used in the net merit index for United States genetic evaluations of Holstein. In buffaloes, length of productive life has been defined as the time between first calving to culling or total days in milk from first calving to last calving (Kalsi and Dhillon, 1982; Umrikar and Deshpande, 1985; Ali, 1989; Dutt and Taneja, 1994) and may be similar to the definition of herd life.

Breeding efficiency is another important determinant of performance involving multiple lactations. There are many ways to determine breeding efficiency but most definitions involve calving interval, number of calvings and age at first calving. An ideal such as calving every 365 days, is also used to compare estimates. Khan et al. (1990) compared the three methods of estimating breeding efficiency in Nili-Ravi buffaloes. They reported that estimates of breeding efficiency depends on the number of lactation utilized by the method of Wilcox et al. (1957), Tomar (1965) and Sharma et al. (1980). Average breeding efficiency varied between 69.9 and 70 percent. Coefficient of variation varied between 15 and 43 percent. However, when similar number of calvings were used, variation in the estimates of breeding efficiency reduced appreciably.

The genetic control of lifetime traits has been reported to have a very wide range. Habitability for the lifetime milk yield for Pakistani and Indian buffaloes ranged from 0.15 to 0.64 (Ali, 1989; Raheja, 1998). In Nili-Ravi buffaloes, Ali et al. (1989) reported heritability of 0.69±0.08 productive life. Whereas in Indian buffaloes lower (0.12±0.02 to 0.17±0.07) estimates have been reported (Umrikar and Deshpande, 1985; Dutt and Taneja, 1994). Singh and Basu (1988) reported that h^2 estimates for breeding efficiency to be 0.38±0.14, whereas the lowest value (0.012±0.04) was reported by Akhtar (1987).

The goal of this study was to evaluate four institutional herds of Nili-Ravi buffaloes genetically and phenotypically for the lifetime traits and estimate their genetic trends.

MATERIALS AND METHODS

Performance records of Nili-Ravi buffaloes from the four Government herds in Punjab, namely Haroonabad, District Bahawalnagar (LESHA) for 1979-2000; Chak Katora, District Bahawalpur (LESCK) for 1971-2000; Khushab, District Khushab (LESKH) for 1979-2000 and Bahadurnagar, District Okara (LPRIBN) for 1971-2000 were used for the present study. At Government farms culling in buffalo is done periodically on the basis of reproductive disorders, low production, age factors and health disorders. No special selection scheme is practiced. Some attention is given to conformation, breed characteristics and milk production. High producing buffaloes are kept as bull mothers and given special attention. Prior to the 1970's natural mating was performed at these farms. Bulls were selected on the basis of their pedigree and categorized A, B, C, D according to the performance of their dams. During 1970's semen collection was started at the State farms and artificial insemination was started along with natural mating system. In Pakistan, buffalo semen is not imported from any other country. It is produced locally at the buffalo semen production unit. In 1980's progeny testing program for buffalo bull selection has been launched in the buffalo breeding areas. No particular system of mating has been adopted. Inseminations are performed at random without any special allocation of specific groups of dams or dams to specific sires. The culling procedure in private small house hold farmers mostly involuntary.

The data consisted of Individual's identity, date of calving, date of drying, dam's date of birth, date of disposal, date of service, lactation milk yield and sire's date of birth. The derived variables were, lifetime milk yield, herd life, productive life, breeding efficiency as defined below.

Lifetime milk yield

The milk yield (kg) accumulated over all completed lactations (Ali et al., 1999).

Productive life

Sum of number of months in milk from each lactation. Each lactation received a maximum credit of 10 months because records >305-days currently are not stored and cows with short rather than long calving intervals accumulated credit than long calving intervals credit faster and can have higher MIM84 VanRadan and Klaaskate (1993).

Herd life

The herd life was defined as the difference (in days) between the date of birth and date of disposal (Smith and Quaas, 1984).

Breeding efficiency

The breeding efficiency was worked out according to the Wilcox et al. (1957) as: $BE (\%) = 365(n-1)/D \times 100$

Where 365 is the standard calving interval, n is the number of calves and D is the total number of days from first to last calving.

Statistical analyses

Following statistical model was used:

$$Y_{ijkl} = H_i+Y_j+Season_k+b_1(Age)_{ijkl}+e_{ijkl}$$

Table 1. Means for lifetime traits in different herds

Herd	Observations	Lifetime milk yield (kg)	Herd life (days)	Productive life (days)	Productive life (days)	Breeding efficiency (%)
LESHA	111	8,844.7±592.9	4,190.3±143.0	1,277.9±75.2	1,244.0±69.1	67.2±2.3
LESCK	281	8,123.3±458.2	3,968.0±110.5	1,207.5±58.1	1,139.0±53.4	70.0±1.8
LESKH	248	5,717.6±449.4	3,900.1±108.4	1,042.1±57.0	985.8±52.4	70.8±1.7
LPRIBN	397	6,587.8±411.6	3,468.9±99.3	843.4±52.2	758.3±48.0	55.8±1.6
Overall	1,037	7,722.9±163.7	3,989.7±40.6	1,137.6±20.5	1,061.3±19.0	64.0±0.6

LESHA = Livestock Experiment Station Haroonabad. LESCK = Livestock Experiment Station Chak Katora.
LESKH= Livestock Experiment Station Khushab, LPRIBN = Livestock Production Research Institute Bahadurnagar.

Table 2. Sources of variation in the lifetime traits

Source of variation	df	Mean square				
		Life time milk yield (kg)	Herd life (days)	Productive life[1] (days)	Productive life[2] (days)	Breeding efficiency (%)
Year of birth	30	89,084,745.6**	7,652,095.8**	1,490,209.1**	1,336,101.7**	524.7**
Herd of calving	3	359,143,000.7**	15,453,948.2**	7,077,975.2**	8,085,349.4**	10,555.4**
Season of birth	3	48,978,073.2^{NS}	3,985,198.2^{NS}	1,011,662.0**	813,031.5^{NS}	660.8^{NS}
Age Code	1	37,737,313.7^{NS}	49,600,129.9**	776,759.1^{NS}	1,057,444.6^{NS}	475.1^{NS}
Residual	999					

** Significant ($p<0.01$), NS = Non-significant.
1 = Productive life defined similar to Ali (1989), 2 = Productive life defined similar to VanRaden et al. (1993).

Where,

Y_{ijkl} = Individual observation on any lifetime trait

H_i = Fixed effect of the herd

Y_j = Fixed effect of year of birth

$Season_k$ = Season of birth (1-4) 1: winter; 2: spring; 3: summer and 4: autumn

b_1 $(Age)_{ijkl}$ = Age at first calving as a covariate (Jairath et al., 1998)

e_{ijkl} = The random error associated with each observation

Analyses were performed using SAS® (1996).

For variance components estimation a uni-variate model was used with random animal effect added to the above model with the assumption of zero mean and $\hat{\sigma}^2_A$. Season of birth being unimportant for most of the traits, was dropped. All the known relationships were incorporated.

For genetic correlation between milk yield and lifetime traits, a bivariate model was used as under.

$$Y = (I_t \otimes X)b + (I_t \otimes Z_1)a + (I_t \otimes Z_2)p + e$$

Where Y is a matrix of dependent variable having vectors of lifetime traits; b is vector of fixed effects; t is number of traits i.e. 2; ⊗ is Kronecker product, a, p, and e are random animal, permanent environment and temporary environment effects; X, Z_1 and Z_2 are incidence matrices for vectors b, a and p (Khan, 1997). Fixed effects included 94 herd-year combinations. For genetic correlations of lifetime traits with lactation length, the above model was modified to replace milk yield with lactation length. The estimation of (co)variances and breeding values were obtained using the Derivative Free Restricted Maximum Likelihood (DFREML) set of computer program (Meyer, 1997).

RESULTS AND DISCUSSION

Lifetime milk yield

The lifetime milk yield averaged 7,723±164 kg (Table 1) in this study. Year of birth and herd were important variation sources. Season of birth and age at first calving did not affect lifetime milk yield (Table 2). Average lifetime milk yield was highest (8,845±593 kg) at LESHA and lowest (5,717±449 kg) at LESKH. The overall phenotypic trend during the period under the study was negative (-280 kg/year) (Figure 1). The heritability (h^2) estimate for the lifetime milk yield was 0.093±0.056 (Table 2).

Lifetime milk yield has been reported to vary widely in buffaloes. Dutt and Taneja (1994) reported an average of 9,993±8 kg for Indian buffaloes, while a very low average of 3,676 kg was reported by Biradar et al. (1991) for Surti buffaloes. The earlier report on Nili-Ravi buffalo for lifetime milk yield of 7,834±6 kg (Ali, 1989), is similar to average yield obtained in the present study.

The difference in means of lifetime traits may be due to the differences in defining and editing data on trait. Variation in parities to be included affects averages. Herd health and reproductive status also affects termination of lactations (Ahmad et al., 1992).

The heritability of lifetime milk yield has been reported to vary widely (0.15 to 0.64±0.16). Heritability estimates in the present study was slightly lower than the previous study (Raheja, 1998) in Indian Murrah (0.15) using Animal Model. The low estimates of heritability of lifetime milk yield suggest that direct selection will not bring much genetic improvement as waiting for buffaloes to be culled will increase generation interval.

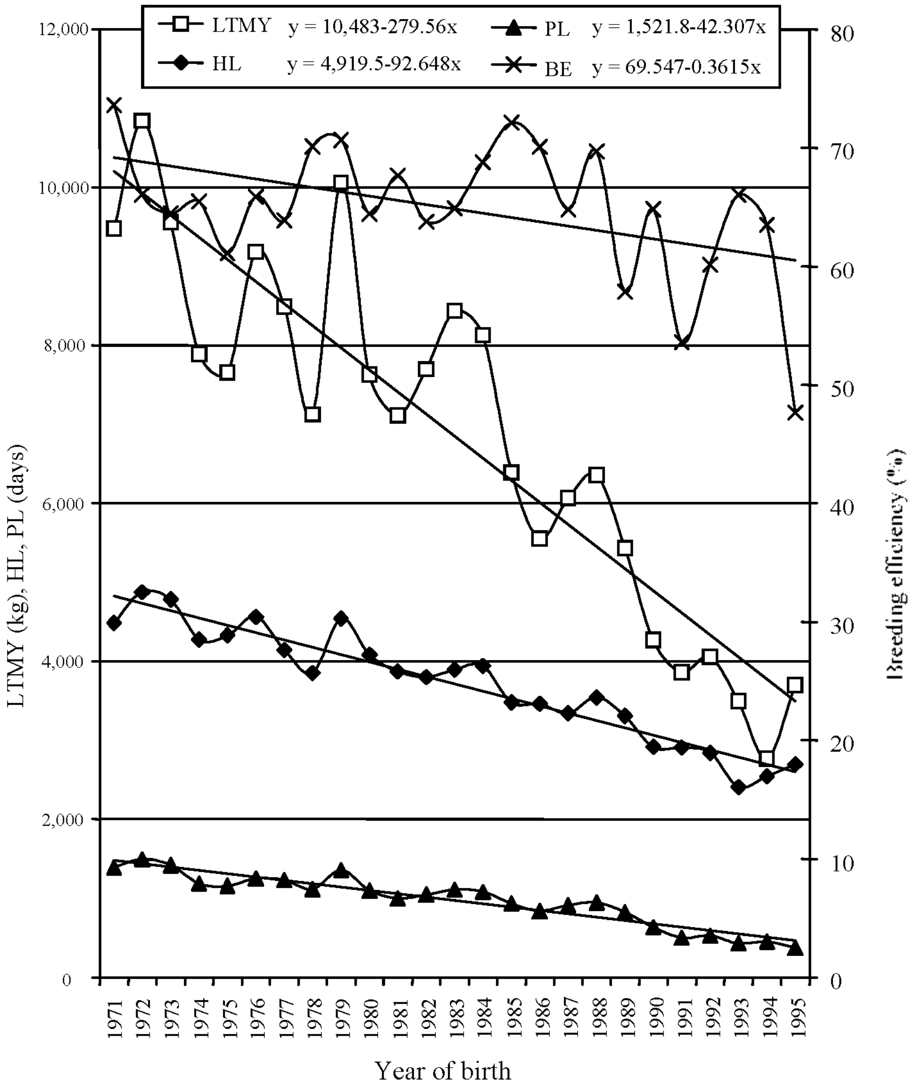

Figure 1. Phenotypic trend in lifetime milk yield (LTMY) (kg), herd life (HL), Productive life (PL) (days) and breeding efficiency (%).

Herd life

Overall mean of herd life was 3,989±41 days (Table 1). Year of birth, herd and age at first calving were important variation sources. Season of birth did not affect the herd life (Table 2). Maximum herd life (4,190±143 days) was observed at LESHA followed by LESCK (3,968±10 days), LESKH (3,900±108 days) and LPRIBN (3,469±99 days). Overall phenotypic trend for herd life in this study was negative (-93 days) but varied among the herds from -86.6 (LPRIBN) to -122 days/year (LESHA) (Figure 1). The heritability (h^2) estimates for the herd life was 0.001±0.055 (Table 2).

Herd life varied widely in different reports on buffaloes. Cady et al. (1983) reported an average of 4,490 days for Nili-Ravi buffaloes, while a very low average of 2,015±42 days was reported by Ali (1989) for the same breed in Pakistan. Previously, Rao and Rao (1996) reported that herd life averaged 3,902 days in Indian Murrah, which is similar to the present study (3,990±40 days). Reproductive failure and low milk yield were identified as the principal reasons for culling of buffalo (Ahmad et al., 1992). Definition of herd life, mastitis and udder problems may contribute to the differences in herd life. Farm differences may be real and represent difference in management practices planned or unplanned (Silva et al., 1986). Phenotypic trends in herd life were negative which may be due to deteriorating health status of these herds as well as reproductive problems because rarely buffaloes were culled due to lower productivity. This may not allow the genetic potential of buffaloes to be expressed fully (El-Arian, 2001).

The genetic control of herd life has been reported to vary widely (0.12 to 0.38) in Pakistani and Indian buffaloes (Raheja, 1998; Ali, 1989). However, studies with reasonably large data sets (Harris et al., 1992) reported very low (0.002±0.07) heritability similar to the present study (0.001±0.05).

Table 3. Heritability (h^2) and variance estimates for different lifetime traits

Traits	Heritability		Variance		CV(%)
	Estimates	SE	σ^2_a	σ^2_p	
Lifetime milk yield (kg)	0.093	0.056	2,140,922.7	23,010,075.3	62.1
Herd life (days)	0.001	0.055	6,409.8	1,390,804.7	29.6
Productive life (days) total	0.133	0.073	51,631.3	373,228.2	53.7
Productive life (305-day)	0.144	0.079	46,933.6	315,241.7	52.9
Breeding efficiency (%)	0.001		0.53	331.2	28.4

Table 4. Genetic (below the diagonal) and phenotypic (above the diagonal) correlations of different lifetime traits

	MY	LL	LTMY	HL	PL
MY		0.67	0.46	0.21	0.31
LL	0.55±0.22		0.30	0.17	0.22
LTMY	0.60±0.01	0.21±0.02		0.70	0.87
HL	0.22±0.19	0.09±0.01	0.20±0.01		0.77
PL	0.26±0.88	0.23±0.34	0.25±0.013	0.63±0.01	

MY = 305-day first lactation milk yield, LL = First lactation length, LTMY = Lifetime milk yield, HL = Herd life, PL = Productive life.

Productive life

Productive life averaged 1,138±20 days when lactation lengths were not truncated (Ali, 1989) and 1,061±19 days when maximum credit for any lactation was restricted to 10 months (VanRadan and Klaaskate, 1993) in this study (Table 1). Year of birth and herd significantly ($p<0.01$) affected the productive life. Age at first calving did not affect the trait (Table 2). Average productive life was maximum (1,244±69 days) at LESHA and minimum (758±48 days) at LPRIBN. The overall phenotypic trend during the period under the study was -42 days/year (Figure 1). The h^2 estimates for the productive life for both definitions were 0.133±0.073 (not restricted the lactation length) and 0.144±0.079 days (lactation length restricted to 305-days), respectively (Table 2).

Productive life has been reported to vary widely in different reports on buffaloes. The maximum (2,672±357 days) and minimum (1,091±51 days) productive life was reported by Pundir (1993) and El-Barbary et al. (1993), respectively. Previously, Reddy and Nagarcenkar (1988) and Thorpe et al. (1994) reported that the productive life was significantly affected by herd and year of calving ($p<0.01$). Non-significant effect of season on productive life has been reported in cattle (Reddy and Nagarcenkar, 1988). The productive life obtained in the present study (1,061 days) was similar to 1091 days reported by El-Barbary et al. (1993). Considerable differences between herds may be due to relative culling rates. The difference may be attributed due to the differences in climatic, managerial conditions and genetic differences in herds. Average lactation length at LPRIBN was longest (303±2 days) and productive life was the smallest as compared to other herds. The reproductive performance of the herd was, therefore, worst. Managemental conditions need to be looked into to improve the situation.

Heritability estimate was slightly higher for the definition in which each lactation was restricted to 305-days and may be favoured for use in future. Heritability estimates in the present study was similar to earlier estimates of 0.17±0.07 by Dutt and Taneja (1994) and in cattle (0.18±0.16) by Singh et al. (2002). Lower h^2 estimates (0.03 to 0.08) have been reported in cattle using the paternal halfsib correlation and Animal Model (VanRandan and Klaaskate, 1993; Vollema and Groen, 1996; Weigel et al., 1997; Vollema et al., 2000).

Breeding efficiency

Breeding efficiency averaged 64.0±0.6 percent (Table 1). Herd and year was important source of variation in breeding efficiency but not season of birth or age at first calving (Table 2). Maximum breeding efficiency (70%) was observed at LESCK and LESKH followed by LESHA (67%) and LPRIBN (59%). Phenotypic trend of breeding efficiency was slightly negative (-0.36 percent/year) (Figure 1). Heritability estimate was close to zero (0.001) (Table 3).

Breeding efficiency varied widely in different reports on buffaloes. Khan et al. (1990) reported an average of 63 percent breeding efficiency in Pakistani buffalo, while maximum (84 percent) average was reported by Baghdasar and Juma (1998). The difference in the breeding efficiency may be attributed to the differences in number of calvings, method of estimation and reproductive management.

The genetic control of breeding efficiency is very low. Previously estimates reported in Pakistan, Indian and Iraqi buffaloes ranged from 0.01±0.04 to 0.07±0.09 (Akhtar, 1987; Dahama, 1995), whereas, high estimates from limited data sets are also available in the literature (Singh and Basu, 1988).

Genetic and phenotypic correlation

The genetic correlation between the first 305-day milk yield, lactation length and lifetime traits (lifetime milk yield,

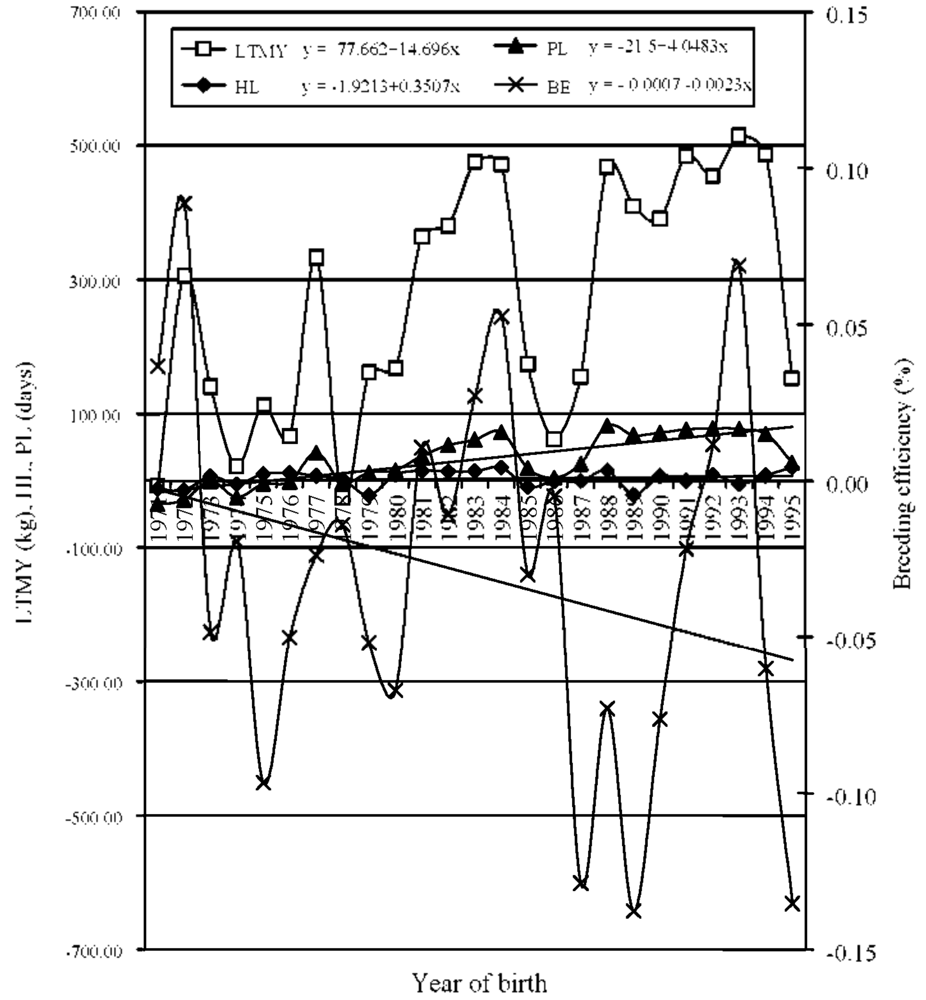

Figure 2. Genetic trend in lifetime milk yield (LTMY) (kg), herd life HL), Productive life (PL) (days) and breeding efficiency (%)

herd life, productive life) are presented in Table 4. The genetic correlation of first lactation 305-day milk yield with lifetime traits are low (0.05±0.001 to 0.26±0.88). The phenotypic correlation of first lactation 305-day milk yield with lifetime traits ranged from 0.21 to 0.46. Genetic correlations between first lactation length and lifetime traits were also low (0.09±0.01 to 0.23±0.34). Phenotypic correlation between the same traits ranged from 0.17 to 0.30. Lifetime milk yield was correlated with milk yield (0.46) and lactation length (0.30) but genetically the relationship was even weaker with herd life (0.20±0.01) and productive life (0.25±0.013). Phenotypic correlation between herd life and lifetime milk yield (0.70) or productive life (0.77) was high. Genetic relationship of herd life with productive life was high (0.63±0.01) but low with lifetime milk yield (0.20±0.01).

Previously, the genetic and phenotypic correlation of first lactation milk yield with lifetime milk yield has been reported to be moderate to high (0.33 to 0.78) in Indian Murrah (Biradar et al., 1991; Raheja, 1998; Tailor et al., 1998). Roxstrom and Strandberg (2002) reported that the high genetic correlation between the milk yield and productive life lowers the risk of being culled due to low production.

Singh and Basu (1988) suggested that the selection on the basis of first lactation milk yield improves the lifetime milk yield. Because low yielding buffaloes are culled, therefore, genetic and phenotypic correlations often are favorable between milk yield and lifetime traits. The genetic correlation between first lactation 305-day milk yield with the lifetime milk yield was high in the present study. High genetic correlation of lifetime milk yield with herd life and productive life indicated that animal with long herd life were also high for genetic merit of total lifetime performance traits (Jairath et al., 1994).

Estimated breeding values and genetic trends

The estimated breeding values (EBVs) for lifetime milk yield averaged +173 kg with the range of -3,360 to 4,082 kg for buffalo population. The genetic trend for the lifetime milk yield was increasing (15 kg/year) and significant

($p<0.01$) (Figure 2). The estimated breeding value for herd life ranged from -221 to 278 days. Annual genetic trend was close to zero for herd life (0.35 days/year) (Figure 2). The EBVs for productive life averaged 23 days with the range of -439 to 538 days for buffalo population. The genetic trend for the productive life was positive (4 days/year) (Figure 2). The EBVs for breeding efficiency averaged -0.034 percent for buffaloes and ranged from -1.0 to 0.87 percent. The genetic trend for the breeding efficiency was close to zero and non-significant for the years under the study (Figure 2).

El-Arian (2001) reported the negative phenotypic trends in lifetime traits. The sub-optimal managerial practices prevailing at the farms under the study were pointed out as a major reason for the development, which did not allow the genetic potential of Murrah buffalo to be expressed fully. This is true for the present study as well. Similarly, in the Israeli Holstein population, the phenotypic trend for herd life was -15 days/year and the genetic trend was 9 days/year (Settar and Weller, 1999). The strong positive genetic trend in unadjusted lifetime traits is an artifact of the nature of culling for production, which results in a negative covariance between genotype and environment for herd life. Selection for production increases genetic merit for unadjusted lifetime traits but also results in a more stringent environment for lifetime traits because of the level of absolute production below which culling takes place is increased (Jairath et al., 1998). The genetic trend in the herd under study for milk yield and lactation length was positive and lifetime traits were expected to behave similarly.

CONCLUSIONS

Year of birth and herd were important variation sources while season of birth did not affect lifetime traits. The phenotypic trend for all the lifetime traits were negative. The genetic control of the life time traits was in the lower range. The genetic trend for all the traits under the study were positive but significant only for lifetime milk yield and productive life. The definition for productive life where each lactation gets credit upto 10 months had slightly better heritability than putting no limit on lactation length and thus may be preferred. Genetically, productive life had positive correlation with lifetime milk yield (low) and herd life (high). The selection for productive life will increase herd life and lifetime milk yield will also improve.

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